Instructions

Text that appears in red should be the answers to the questions, which will come only after the learner has entered his/her answer in a box.

Text in pink is an instruction to the online designer.

Wherever [ ] boxes are provided, it means the course expects the learner's input. There should be a 'Next' button provided for the user after she fills her response in the box.

Density and Floatation

Find out 10 things around you, maybe in your kitchen. For example: whole chana (grams), rice, peanut, plastic pieces, candle, steel bowl, steel spoon, steel plate, knife, honey, oil.

Take a bucket of water. Begin with solids. Hold the solid object in the middle of water. First ask yourself 'Will it float or sink? What is my prediction?' Think for a moment in your mind, decide and then release.

See whether it goes up in the water or down. Are you surprised with the behaviour of some things? Did it behave differently from what you had expected?

Float or sink?

Coming to liquids, decide whether you expect the liquid to float or sink in water. Now put a drop on the surface of the water. What happened?

We see many things floating and sinking. At times human beings float on water, but at other time they drown in pools, rivers or lakes. Is this not puzzling?

What makes objects float or sink?

Let us begin our exploration.

What decides sinking or floating?

Tick one or more statements that sound correct to you:

The user ticks on one or more of the following options. What she ticks should be highlighted.

A. Lighter objects float.

B. Heavier objects sink.

C. Weight does not determine/decide whether an object floats or sinks.

D. Weight **alone** does not determine whether a body floats or sinks

E. Material of the object decides whether an object floats or sinks

F. Shape decides whether an object floats or sinks

G. Volume decides whether an object floats or sinks

H. Volume **alone** does not determine whether a body floats or sinks

Let us examine each statement a bit more. After each statement you have to reflect whether you agree or disagree, and why. Each time you write agree or disagree and click on the next button, you will receive something more to think about.

Lighter objects float. **Agree/disagree**
A needle or pin is light but it sinks.

Heavier objects sink. **Agree/disagree**
A steel pan which is heavy floats.

Weight does not determine/decide whether an object floats or sinks. **Agree/disagree**
But if we take exactly the same sized piece of wood and iron, wood floats and iron sinks. And wood feels lighter, iron heavier. So it must have something to do with weight.

Weight **alone** does not determine whether a body floats or sinks. **Agree/disagree**
Take exactly same weight of wood and iron. Wood still floats and iron still sinks. So the above statement seems true. But if weight alone does not decide floating, what else decides the matter?

Material decides whether an object floats or sinks **Agree/disagree**

The above statement seems true. Wood and wax float and iron, steel and stones generally sink. But there seems to be a problem. A steel vessel and an iron ship float. So there has to be some relation with shape.

Shape decides whether an object floats or sinks **Agree/disagree**
Yes, there seems to be some relation with shape. Because a steel spoon sinks and a steel pan floats. But this cannot be the only relation, since a wood spoon will float and a steel spoon of exactly the same shape will sink.

Volume decides whether an object floats or sinks. **Agree/disagree**
Yes, there seems to be some relation with volume too. Because when a steel spoon sinks and a steel pan floats, the pan occupies much more volume. But if we took a solid block of steel as big as the pan, it would sink.

Volume alone does not determine whether a body floats or sinks **Agree/disagree**
That seems to be correct too. Because whatever volume of wood we take, it always floats!

This is like a mysterious detective story. By the end of our explorations we must figure out WHO exactly is the culprit, causing sinking or floating!

Measuring volume

How do we find the volume of any matter?

Volume of regular solids like cube, sphere, cylinder etc. can be determined using geometrical formulae e.g. the volume of a regular cube is length x breadth x depth.

Looks like finding the volume of regular solids is simple, but what about liquids? Think how you would measure the volume of a liquid, and click next.

We do it in daily life when we measure the volume of milk or oil, using a vessel of known volume. We may use a measuring cylinder, with volume measurements marked on it.

Volume of irregular solids

Irregular solid shapes like stone do not have a formula for volume. How do we find out their volume?

Your measuring jar can measure not just liquid, but also the volume of irregular solids!

Since solids and liquids occupy a fixed volume, and they do not let other matter come in the same space, they displace each other, and allow measurement of volume.

Recall the famous crow story. He knew that solids will displace a liquid from its place. So he used it to push up water.

We can use the same technique the crow used. When we drop a stone (solid object) in water, it displaces water equal to the volume of the stone.

Measuring volume by displacing liquid

If we can collect the water displaced because of the stone, we can measure its volume.

1. Take a plastic mug which has a beak as shown in the figure.
2. Fill the mug with water till it starts overflowing. Let the flow stop completely till the last drop.

3. Keep a container next to the mug so that the water flowing through the beak of the mug can fall into the container

4. Lower the stone into the mug and collect the overflowing water till the last drop.

5. Using the measuring jar, measure the volume of the water collected. For greater precision, you may use a syringe (without a needle) to draw water from the container and calculate the volume. Syringes also have volume measurements marked on them.

Are Weight and Volume related?

If you took exactly the same sized stone and a potato, would they weigh the same? If you hold each in your hands, what would you feel? Which do you predict would be heavier? What about same size of thermocol or iron? Can you put these in increasing order of weight if you took **exactly the same volume** of each?

Potato, stone, thermocol, iron, wood

…….< ……………<………….<…………..<…………..

Thermocol< wood< potato< stone< iron

Similarly, suppose you took **exactly the same volumes** of water, honey and oil in 3 different cups, would they weigh the same? Which would be more or less?

………….<………………<………….

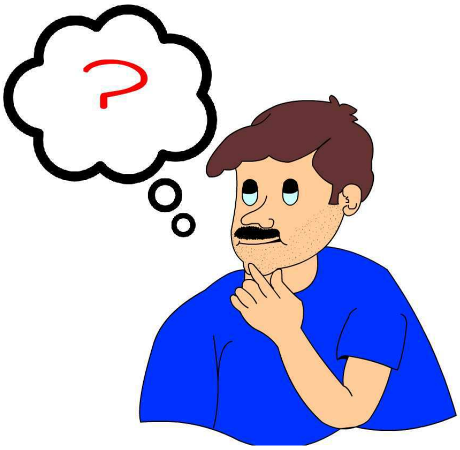
Oil < water< honey

What do we know about these materials which helps us make the prediction?

Let's explore this further.

Suppose we take different volumes of water (e.g.: 100mL, 500mL, 1000mL) and weigh each in grams. Now we find the **ratio** of weight and volume for different quantities of water. What is the ratio we would get each time?

Within the limitation of experimental errors, we find that weight to volume ratio remains fixed. For water it is close to **1 every time** (if weight is taken in grams and volume in mL).



Will other substances show the same property?

Is the ratio of weight and volume same for wood and water?

<VIDEO> Take 3 different sized wood pieces. Measure their volumes. Measure their weights using a spring balance.

(To do this experiment yourself, you can take three different sizes of potato.)

Fill up in the following:

1. Ratio of weight/volume for first piece ………………
2. Ratio of weight/volume for second piece …………….
3. Ratio of weight/volume for third piece ………….

Is the ratio constant or changing? **Constant/changing**

Constant. We see that whatever is the weight and volume of wood in different cases, the **ratio weight/volume** turns out to be the same every time! It seems like a property of the wood itself. This ratio is called **density** of the wood.

From the above tables, compare the density of wood and water.

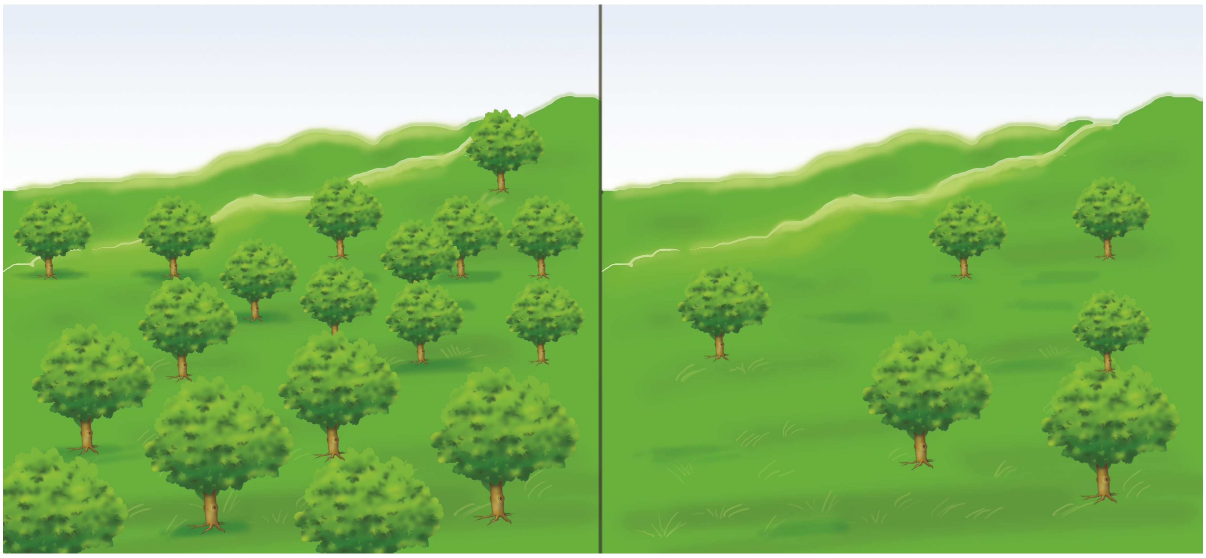
Is the density of wood more than density of water?

No

If we try this for some more homogeneous substances like iron, oil, plastic etc., we realise that density is a fundamental property of a substance.

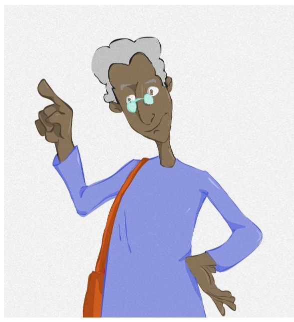
What is density?

Density is a very important property of the material because it describes how much weight is contained in one unit volume of the material (or we say, weight **per unit** volume). It allows us to compare any two substances, in whatever shape or size we see them, to see how much one unit volume of each weighs.



If you recall, in ordinary usage we call a forest 'more dense' if it has more number of plants packed in the same area as compared to another forest which has lesser no. of plants in the same area. In this sense, the word 'dense' is talking about how packed a region is with plants. In the scientific usage, the term density is describing ***how packed a volume (or space) is with weight***. More density in the scientific sense would mean more weight is packed in a material with greater density, as compared to a material with less density.

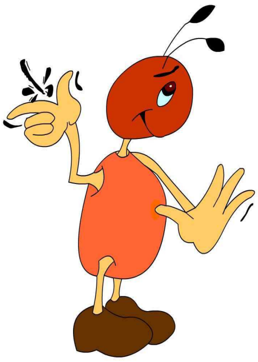
Note: We have not used mass for finding density and are using weight, though mass is the correct concept. This has been done keeping in mind introductory levels. For children at this level, mass is too abstract a concept and is often not introduced or understood.



Material	Density (g/mL)	More or Less than density of water	Predict whether it will Float/Sink
Iron	7.8	More/less	Float/sink
Glass (window)	2.7	More/less	Float/sink

Stone	1.5	**More/less**	**Float/sink**
Stainless Steel	8.05	**More/less**	**Float/sink**
Water	1	**More/less**	**Float/sink**
Oil	.9	**More/less**	**Float/sink**
Wood	.7	**More/less**	**Float/sink**

Materials generally sink in water if their density is more than that of water and floats if it is less than that of water. So our mystery is solved!!



Oh really? You have forgotten the observation "a steel spoon sinks and a steel vessel floats." Both have the density of steel which is more than that of water. But somehow a steel vessel floats.

Oh! Oh! Oh! So we need to explore more. Let's do some more experiments and observations.

The puzzle of a flour-ball and a flour-boat

Knead wheat flour (atta) with little water, so that it is hard, and make 2 equal sized balls. Apply oil over both the balls so that when dropped in water it does not become soggy soon. (You can also use plasticine). First drop one ball in water and observe. Next, change the second ball into a boat shape, put it in water, and observe what happens.

1. Why did the flour ball sink?

   Because the density of flour ball is more than density of water. This seems simple.

2. Why did the flour boat float?

   It seems somehow the overall density of the boat has been reduced because of changed shape. But how can that be, if we say density is an inherent property of the material? So here lies our real puzzle.

3. What are we altering to reduce the density of boat versus the original ball? (tick the correct ones)

a. Decreased the weight of the boat
b. Decreased the volume of the boat
c. Increased the volume of the boat
d. Increased the weight of the boat

We choose option C. But this has to be looked at carefully. We will do it further.

4. What contributed to the decrease in density of boat versus ball thereby making it to float? (tick what seems correct to you)

   a. Changing the closed ball shape to open boat shape
   b. Weight of air in boat shape decreased the weight of boat significantly
   c. Volume of air in boat shape contributed to increase in volume of the total object

We choose option a and c. It is important to see that earlier the ball was a single object made of a single substance (kneaded flour), but now it has no longer remained an object made out of a single material. It is made of kneaded flour and air. Its overall weight= weight of flour + weight of air, Overall volume= volume of flour+volume of air

Can we make sinking objects float?

Materials: Few chana-grams (around 10), one/two rupee coin, small plastic bag, rubber band, mug of water

Notice what happens when we drop coin, chana, plastic cover separately in a mug of water

1. Put the coin in the bag and tightly tie it with a rubber band

Drop this bag with a coin inside in a mug of water, what happens?

Sinks/Floats

Yes, the bag sinks

2. Remove the rubber band and blow some air into it and tie the rubber band towards the mouth of the bag. Drop this bag with coin and air in a mug of water, what happens?

Sinks/Floats

Observe that the bag floats

3. Remove the rubber band add few chana to the cover and tightly tie it with rubber band and drop it in a mug of water. What happens?

Floats

Sinks/Floats

Both chana and coin sinks which means density of coin and chana are more than water, but when dropped together in a cover it floats.

Similarly, coin in a cover without blowing air sinks, but with air it floats.

Can you think why?

Ratio of coin's weight to its volume (coin density) is more than the ratio of packet's (coin & chana in a bag) weight to packet's volume (packet's overall density).

Similarly adding air to the cover reduced the density of the packet containing coin and air as compared to the density of the coin.

This implies that mixing objects (object1 and object2) might affect the density of the final object (object3) irrespective of the density of object1 and object2 as the weight/volume ratio may change in object3.

Mothball dance!

Materials: Moth ball, soda (or any 'carbonated' preferably transparent soft drink), Glass

If you do not have a soft drink, then the experiment also works by mixing vinegar and cooking soda, and putting mothballs into it.

Video to be added

Fill half of the glass with soda and dilute with equal amount of water. Drop a mothball in. Wait and observe what happens.

1. What happens to the mothball as soon as we drop it in the soda?

sinks

2. Why does a mothball sink as soon as we drop the mothball in soda?

   Density of mothball is more than that of soda

3. What happened to the mothball after some time?

   Floats

4. When you observed few minutes. What did you notice?

   The mothball sinks, then floats again, then sinks

5. What change did you notice on the mothball as it goes up in the soda?

   Gas bubbles are attached to the moth ball

6. Since we do not add anything to the soda, its density will not change. But how does the density of the mothball change? [Notice that no chemical reaction changes the density of either the soda or the mothball]

Density of the mothball is reduced by low density gas bubbles attaching themselves to the ball. So its 'overall volume' increases. Overall volume= volume of mothball + volume of gas bubbles. Since weight of gas bubbles are not much, weight of moth balls with bubbles re4mains almost same. This results in the ratio of weight to volume, in other words density decreasing.

7. Why does the mothball keep sinking and floating alternately?

When the mothball reaches the surface, some of the gas bubbles burst, and its overall volume decreases. As a result, overall density increases and it sinks. After some time, more gas bubbles are formed and attach themselves to the mothball. Thus the overall volume increases, density decreases and it floats up again.

A floating and sinking egg

Materials: Egg, salt, water, glass, spoon

Procedure

Half fill the glass with water. Mark the water level with a pen outside the glass.

Using a spoon, carefully put the egg in water.

1. Does the egg sink or float?

Take out the egg. Add 4-5 spoons of salt to the water and mix thoroughly. Put the egg in water again. Observe what happens.

Take out the egg and slowly fill the glass with water.

Put the egg in again.

2. Does the egg sink or float in salt water now?

3. What happened to the salt inside water? Could we see the salt after we mixed it in water?

No, the salt dissolved in water.

4. When salt dissolved in water, did the volume of water increase?

Water level can be checked to see that volume did not increase.

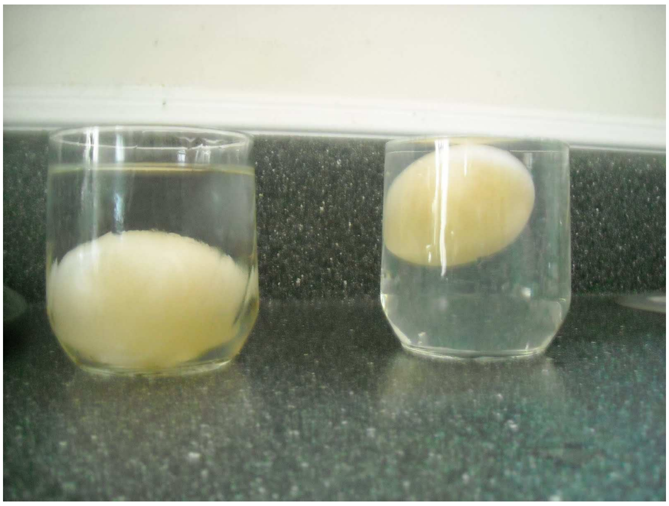
5. When salt was dissolved in water, did the weight of water increase, decrease or remain the same?

Weight of water can be checked to see that it increased.

6. Volume of water did not increase but its weight did. What effect does this have on density?

The density of water will increase.

Notice that in the egg experiment we are changing the density of the liquid, without altering the density of the solid object.



Becoming lighter in liquid

Loss of weight in liquid

Tie a stone or some weight to a thread and hold the thread with your fingers. Feel the pull of the weight on your hand. Now lower this weight inside water. Do you feel a difference in the pull?

Does the stone now feel lighter or heavier? **Lighter/heavier**

Yes, it feels lighter.

If you have sat in water or tried to swim, as soon as you enter water you feel as if you have less weight, as if water is lifting up your body. It seems as if liquids provide an upward force to any object that is put inside them.

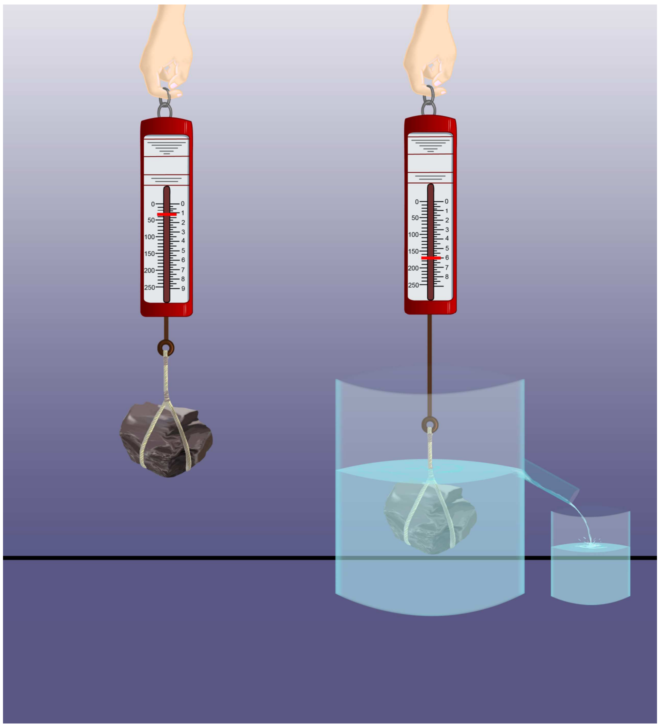
Does this force depend on the object's shape, size, volume and density etc.? Will this decide what will float of sink in a liquid?

Let us explore this more.

Weigh a stone in air and water

Tie a stone with a piece of thread and tie it with a spring balance. Note its weight. Let us call it A.

Remember what we did to measure volume of stone? This time we will again dip this stone in water, but we will also be interested in the water that is spilt by the stone.



Dip the stone in water and note the new weight on the spring balance. Let us call this new weight B.

As shown in the picture, carefully collect the water that is spilt out of the mug because of the stone. Call this C. We call this water the water 'displaced by the stone'. Weigh this water (don't forget to subtract the weight of the glass in which you collected the water).

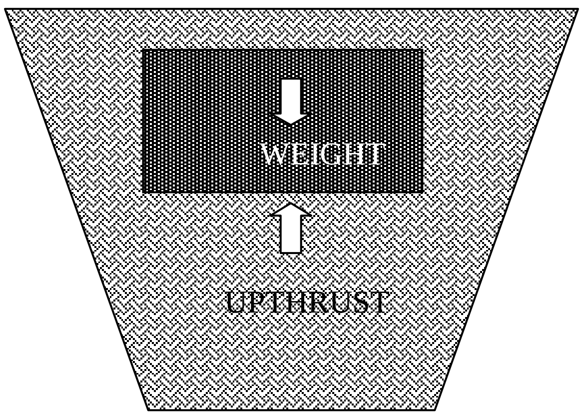
Find out A-B, i.e. weight of solid in air- weight of solid in water. What does it give you? It gives us the weight loss of stone in water. Compare it with C. What do you notice?

We find that A-B is nearly same as C. That means the stone becomes lighter by the same amount of weight as the weight of displaced liquid. Is this not strange? Yes, but this is what is called Archimedes principle.

Archimedes Principle

Archimedes principle says that an object when dipped in a liquid experiences an upward force, as if the liquid is pushing it or supporting it from below. This upward force is named as **upthrust**. It is upthrust that decides whether bodies will sink or float.

Look at this block immersed in water with forces shown:

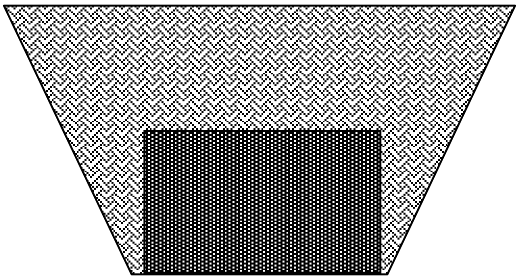


What happens when upthrust is more than weight?

What do you think will happen if:

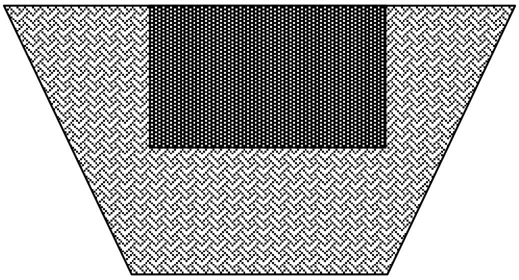
Weight> upthrust?

Upthrust is unable to hold the body up in the liquid and the body sinks.



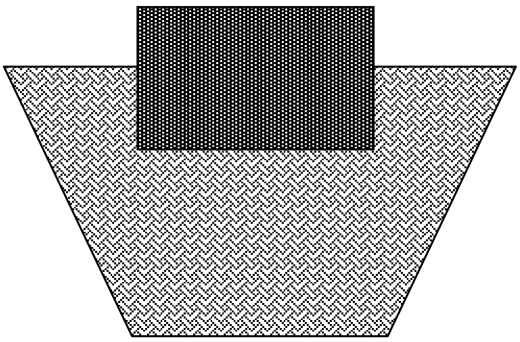
Weight = Upthrust ?

Weight and upthrust cancel each other and the body floats.



Weight< Upthrust ?

The upthrust is more than the weight, so it pushes the body up till the body is only partially immersed in the water. By being partly immersed the upthrust becomes less so that it becomes equal to the weight, and the body becomes stable. Can you figure out how?



For this you will have to recall that Upthrust = Weight of liquid displaced. In the third case, the liquid displaced becomes less than the volume of the body. If the body was fully immersed, it would displace a volume equal to its own. But if only a part of it is immersed it displaces lesser amount of liquid, and therefore experiences lesser upthrust.

A question arises as to why upthrust is linked to weight of the liquid displaced. We will figure this out in the topic fluid pressure, for which you can click here.

Assignment

1. In the egg experiment, will the egg float if we add sugar instead of salt? Why?

2. Will the egg float if we add fine sand instead of salt? Why?

3. Have you observed what happens when a pod of green peas (unshelled) and some fresh peas (shelled) are dropped in water? Can you guess what is making the pod float?

4. Ramu went to a shop to buy a litre of oil packet. After he bought it, he saw at the back, written in small letters — 910g.he had expected to receive 1000g of oil in one litre packet. He shouted "Aaa I am cheated!" Do you think Ramu is really cheated?

5. Have you noticed that ice floats on top of water with some portion above water and much below. What do you think will happen if we cut of the portion that is visible on top of the water surface?